**City of Phoenix
Case Study**
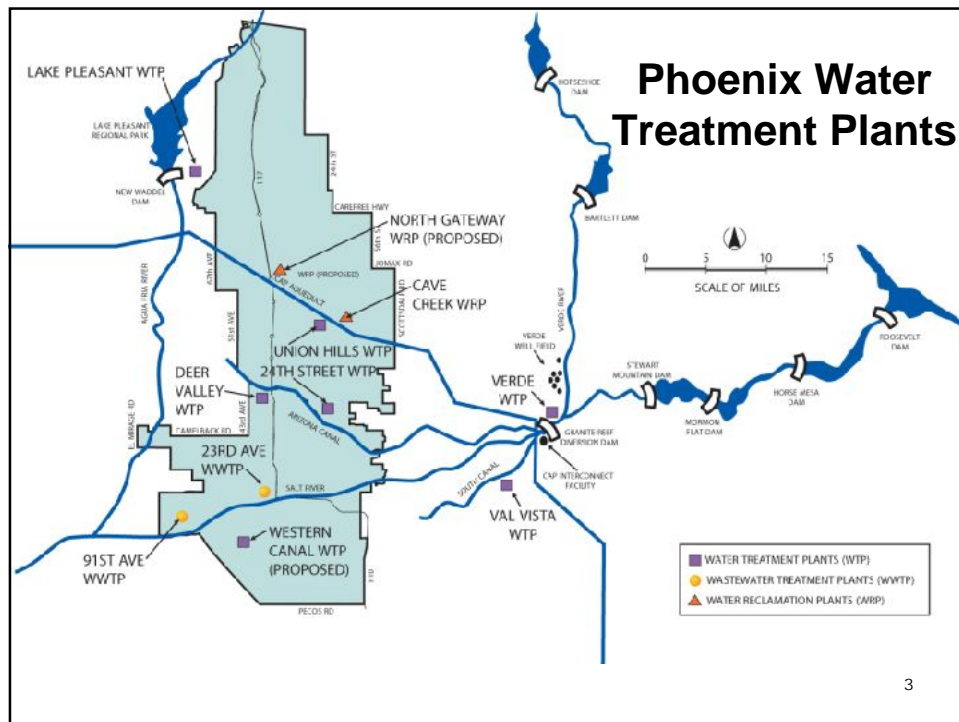
**Paul Kinshella, P.E.
Treatment Plant Engineering Superintendent
City of Phoenix**

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Purpose

Evaluate alternative disinfection methods to reduce risk associated with gaseous chlorine at City of Phoenix WTPs and WWTPs.

WTPs & WWTPs Alternative Disinfection Study

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Phoenix Water Treatment Plants

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Existing System

- 17-Ton Tank Truck Gaseous Chlorine
  - Val Vista WTP
  - Union Hills WTP
  - 23rd Avenue WWTP
  - 91st Avenue WWTP
- 1-Ton Container Gaseous Chlorine
  - Squaw Peak WTP
  - Deer Valley WTP
- All Chorine Contained in Secure Buildings
- Scrubbing for Chlorine Leaks

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Evaluated Alternatives

Facility Name	Existing System	Selected Alternatives				
		1-ton Cl2	Bulk Hypo	Onsite Hypo	Onsite Gas	UV
VVWTP	17-ton Cl2	X	X	X	X	X
UHWTP	17-ton Cl2	X	X	X	X	X
DVWTP	1-ton Cl2	-	X	X	X	X
SPWTP	1-ton Cl2	-	X	X	X	X
91st WWTP	17-ton Cl2	X	X	X		X
23rd WWTP	17-ton Cl2	X	X			X

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Benefits and Challenges of Alternative Disinfection Methods vs. Chlorine

- **Benefits**
  - **Risk Reduction**
- **Challenges**
  - **Increased cost**
  - **Lower reliability and increased complexity**
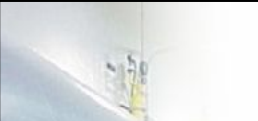 - **Chlorine Solutions Lose 50% of Chlorine Concentrations in 1 Week (Summer Temperatures)**

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Evaluation Methodology

- **Cost**
  - **Capital**
  - **O&M**
  - **Life Cycle**
- **Non-Monetary Benefits and Impacts**
- **Risk Reduction (on and off site)**

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Design Criteria

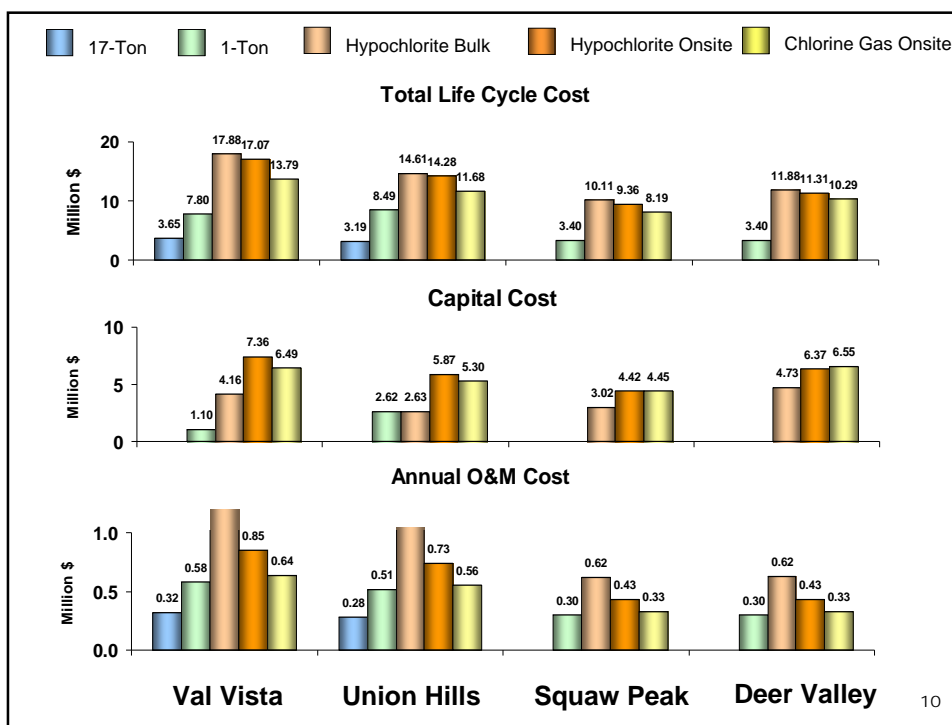|	Units	Squaw Peak	Deer Valley	Val Vista	Union Hills
Maximum Day Capacity	MGD	140	150	220	160
Average Production	MGD	80	80	160	140
Ultimate Capacity	MGD	140	150	280	240
Average Historical Chlorine Dosage	mg/L	3.2	3.1	2.8	3.0
Chlorine Dosage	mg/L	4.0	4.0	4.0	4.0
15-Day Storage at Maximum Day Flow	lbs Cl_2	70100	75100	110100	80100
1-Day Chemical Usage at Average Flow	lbs Cl_2/day	2700	2700	5300	4700

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Hypochlorite
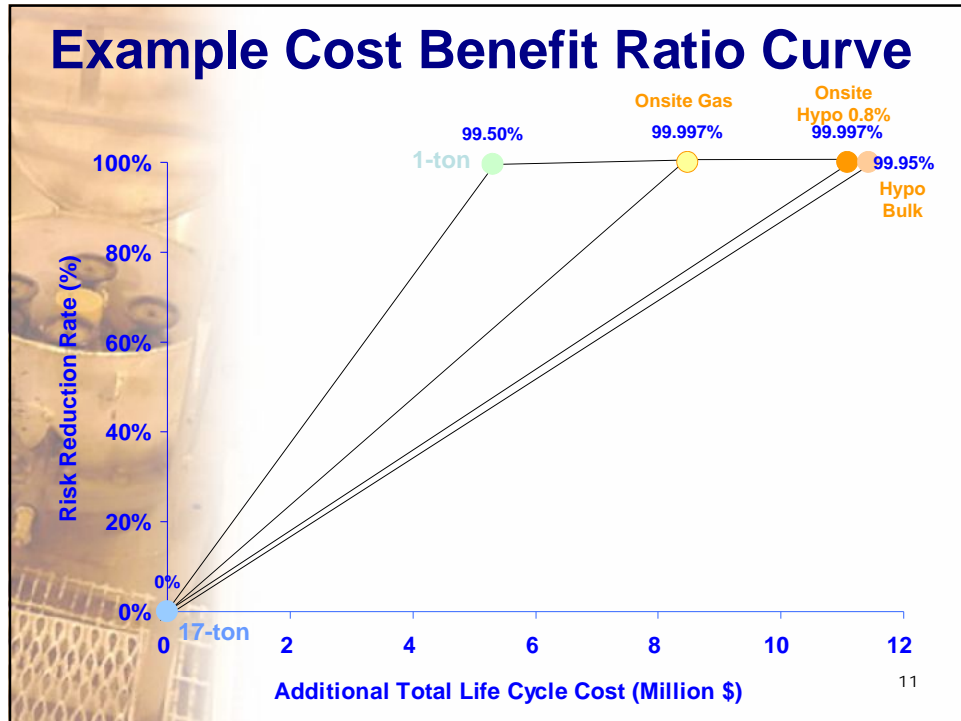# Tank Truck Delivery Requirements

- Based on average flow, 4 mg/L and 5,000 gal/delivery
  - 2 per day at Val Vista
  - 1 per day at Union Hills
  - 1 every 2 days at Squaw Peak
  - 1 every 2 days at Deer Valley

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Total Life Cycle Cost

Legend: 17-Ton | 1-Ton | Hypochlorite Bulk | Hypochlorite Onsite | Chlorine Gas Onsite

Val Vista: 3.65, 7.80, 17.88, 17.07, 13.79
Union Hills: 3.19, 8.49, 14.61, 14.28, 11.68
Squaw Peak: 3.40, 10.11, 9.36, 8.19
Deer Valley: 3.40, 11.88, 11.31, 10.29

Capital Cost

Val Vista: 1.10, 4.16, 7.36, 6.49
Union Hills: 2.62, 2.63, 5.87, 5.30
Squaw Peak: 3.02, 4.42, 4.45
Deer Valley: 4.73, 6.37, 6.55

Annual O&M Cost

Val Vista: 0.32, 0.58, 0.85, 0.64
Union Hills: 0.28, 0.51, 0.73, 0.56
Squaw Peak: 0.30, 0.62, 0.43, 0.33
Deer Valley: 0.30, 0.62, 0.43, 0.33

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Example Cost Benefit Ratio Curve

Onsite Gas **99.997%**

Onsite Hypo 0.8% **99.997%**

99.50%

1-ton

99.95%

Hypo Bulk

Risk Reduction Rate (%)

100%
80%
60%
40%
20%
0%

0%

17-ton

Additional Total Life Cycle Cost (Million $)

0   2   4   6   8   10   12

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Non-Monetary Evaluation

- **Security**
- **Water Quality**
- Safety
- Upgradeability
- Constructability
- Re-engineering
- Land Requirements

- Effective Space Utilization
- Maintenance Requirements
- Operational Complexity
- Regulatory Compliance
- Impact on Operation
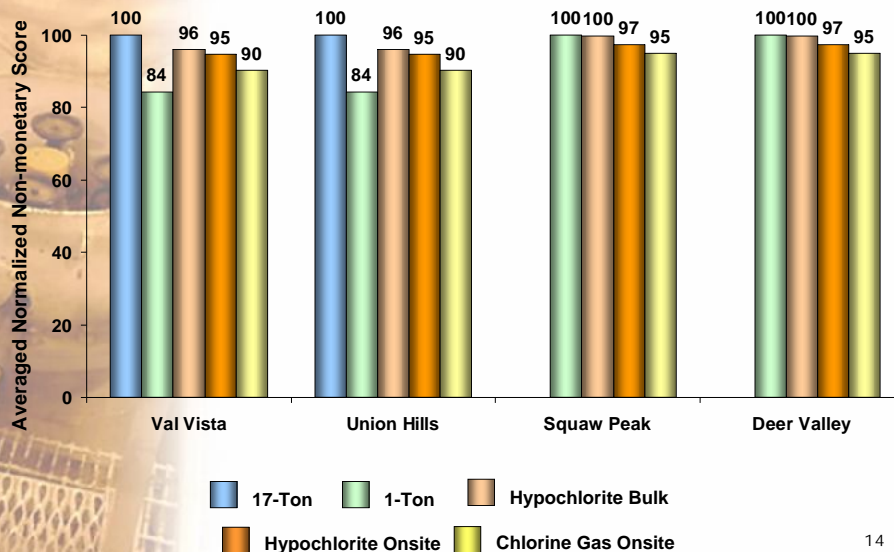- Risk Management Plan

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Transportation Risk Assumptions

- Only On Site Generation Decreases Chlorine Shipment to the Valley
- All Other Options - Chlorine Gas Transported to Repackaging Point in Rail Cars
- Smaller Containers
  – Less Risk

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Non-Monetary Evaluation

Averaged Normalized Non-monetary Score

	Val Vista	Union Hills	Squaw Peak	Deer Valley
17-Ton	100	100		
1-Ton	84	84	100	100
Hypochlorite Bulk	96	96	100	100
Hypochlorite Onsite	95	95	97	97
Chlorine Gas Onsite	90	90	95	95

Legend: 17-Ton, 1-Ton, Hypochlorite Bulk, Hypochlorite Onsite, Chlorine Gas Onsite
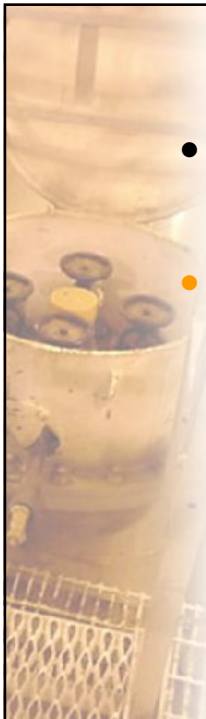
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Conclusions

- Alternative disinfection methods reduce risk
- Alternative disinfection methods are more expensive than gaseous chlorine
  - Capital cost
  - Annual operating cost
- Converting to ton cylinders provides risk reduction with less cost impact

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Recommendations

- A risk reduction of 99.5% is acceptable

- **1-ton gaseous chlorine** recommended
  - **Val Vista WTP**
  - **Union Hills WTP**
  - **23rd Avenue WWTP**
  - **91st Avenue WWTP**

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Ask the Experts

Paul Kinshella   **Scott Dewhirst**   **Bill Bellamy**

E-mail your question with your first name, city
and state to online@awwa.org.

Please specify to whom you are addressing
the question.

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